THURSDAY, SEPTEMBER 6, 1906.

NILE STUDIES.

The Physiography of the River Nile and its Basin. By Captain H. G. Lyons, Director-General, Survey Department. Pp. viii+411; with 48 plates. (Cairo: National Printing Department, 1906.)

WHEN a British army was first sent to occupy Egypt, the late Prof. Huxley called upon the Royal Society to appoint a committee to arrange for a systematic study of that most interesting country. He justly pointed out how much the French Government had accomplished in the promotion of scientific research and in the publication of its results during their short period of occupation at the beginning of last century, and he declared that it would be a national disgrace if we failed to accomplish something of the same kind with our much greater opportunities.

The publication of the work before us, and of others of a similar character, serves to show that England has not been unmindful of her responsibilities or neglectful of the opportunities which have resulted from our close association with the Egyptian Government for more than two decades. Captain Lyons, who organised the Geological Survey of Egypt—some of the admirable publications of which have been reviewed in the pages of NATURE—has now become head of the whole Survey Department of Egypt, and is administering its affairs with characteristic energy and ability.

The discovery of the Lake district of Equatorial Africa by Speke and Grant, with the surveys and observations of Gordon, Emin, Schweinfurth, Junker, and others, has afforded a safe basis for the treatises on Nile hydrography by Klöden, Lombardini, Chavanne, and de Martonne; but since the fall of Omdurman in 1898, and the consequent opening up of the Sudan, much new material has been made available. Systematic meteorological records have been collected at various stations in Uganda, Abyssinia, and the Sudan, and careful measurements have been made of the levels, at different seasons of the year, of the several lakes and of the amount of water discharged by each of the Nile tributaries. All these sources of information have been admirably utilised by Captain Lyons in his survey of the present state of our knowledge of Nile hydrography.

After a very interesting discussion of the climate and rainfall of the districts from which the waters of the Nile are supplied, Captain Lyons proceeds to describe in detail the eight regions into which the Nile basin may be conveniently divided. Recent surveys in most of these districts have given much greater precision to our knowledge of their physiography, geology, meteorology, and other natural features.

The *Lake Plateau,* which has an average elevation of about 5000 feet, is composed of various metamorphic rocks. The central part of the area is occupied by the great Lake Victoria, while in its western part is the deep rift valley with Lakes Albert Edward and Albert. The district is characterised by rapids and marshes, no regular flow of the streams having been established by erosion, but the effective supply to the Nile from the Victoria Lake varies from 500 cubic metres to 1000 cubic metres per second.

The basin of the *Bahr el Jebel, Bahr el Zaraf,* and *Bahr el Ghazal,* although having a very heavy rainfall, really absorbs, not only this, but a considerable part of the water supplied to it from the Lake Plateau. The rivers wind through level alluvial plains, and support a great marsh vegetation (the "sadd"), consisting of papyrus and various reeds with some floating plants, and evaporation and absorption by vegetation take up, not only the whole of the considerable rainfall, but diminish the amount coming from Lake Victoria by from 4 per cent. to 52 per cent.

The *Sobat Basin* is occupied by a comparatively short river with a rapid fall, and adds an appreciable but varying amount to the waters coming down the White Nile.

In the *White Nile Basin* we find that we have the most constant element in the supply of the Nile waters. The 1500 million cubic metres of water from the Sobat flood are supplied to the Nile during October, November, and December, thus modifying the fall in the water-level of the river during those months.

The Blue Nile, the Atbara, and the Khor el Gash.—These rivers drain a plateau with an elevation of from 6000 feet to 10,000 feet. Although exact information concerning the distribution of rainfall in various parts of the Abyssinian highlands is still wanting, there can be no doubt that the rainfall is very great. The regular northward movement of the rain-belt during the monsoon season leads to the flooding of the Blue Nile and Atbara, and the annual Nile flood in July, August, September, and October. The volume and continuance of this flood are clearly dependent, firstly, on the amount of rainfall in the Abyssinian highlands, and secondly, on the great length of the river courses, with their deeply-cut channels, ensuring a regulation of the water supply during torrential rains. Captain Lyons directs attention to the possible interference with this latter element in the production of the periodic Nile floods, which may result from the extensive afforestation which is said to be going on in Abyssinia.

From *Khartoum and Berber to Aswan* the united waters of the White Nile, Blue Nile, and Atbara flow in a single stream, which is eroding its bed with considerable rapidity, there being some cataracts but no flood plains. The waters of the Nile have in this part attained their maximum, and in its course northward the river is constantly losing by evaporation and the withdrawal of its waters for irrigation.

From *Aswan to Cairo* the Nile flows in a depression in which it has deposited a considerable thickness of alluvium, and the river winds through the flood plains thus formed. During the fifty centuries of which we have a record, the Nile appears to have deposited a thickness of 16 feet or 17 feet of alluvium in this part of its course, and the silting up of various water

channels and the reclamation of land in consequence have resulted. It is in this way that the lake occupying the depression of the Fayum has been diminished in area.

The floods in the *Nile Delta* of which records have been kept, that are trustworthy for the past 175 years at least, have been critically studied by Captain Lyons with the view of discovering the determining causes of their variations. While no regular periodic alternations of high and low floods can be detected by the study of these records, their dependence on the rainfall and the distribution of atmospheric pressure in the highlands of Equatorial Africa is very apparent. There is reason to believe that more numerous, systematic, and complete meteorological observations in the districts outside Egypt may enable us, in the end, to predict from month to month the probable fluctuations of the annual Nile flood.

The space at our command has only permitted the notice of a few of the more salient features of this very interesting volume. In conclusion, we must congratulate Captain Lyons and the Egyptian Government upon the great amount of valuable work which has been accomplished and is still in progress. A word of praise must also be added on the excellent typography of the volume, and the admirable plates with which it is illustrated.

J. W. J.

THE HISTORY OF DETERMINANTS.

The Theory of Determinants in the Historical Order of Development. Part i. Second edition. General Determinants up to 1841. Part ii. Special Determinants up to 1841. By Dr. T. Muir, C.M.G., F.R.S. Pp. xii+492. (London: Macmillan and Co., Ltd., 1906.) Price 17*s*. net.

A MATHEMATICAL history of the right sort is much more than a mere bibliography, and in some respects is more valuable than a treatise on the subject with which it deals. It helps us to see how mathematical ideas originate, and how, as they become familiar, the symbolism by which they are expressed becomes compact and appropriate. This is especially the case with determinants, because a determinant is essentially a comprehensive symbol, and it would perhaps be more proper to speak of the calculus than of the theory of determinants. It may seem strange, at first sight, to find a history so large as this dealing with a subject so limited; but no one can complain that the author is either diffuse or irrelevant, and his work may be praised without restriction as a model of its kind.

It is unnecessary to say much of the first part, which is mainly a reprint of the volume which appeared in 1900. Dr. Muir has written a new introduction, and added a few additional notices. Two things cannot fail to strike the reader of this part. The first is the great supremacy of Cauchy and Jacobi in everything relating to choice of notation and clearness of statement; the other is the great and long unrecognised ability of Schweins. Schweins, in a way, brought this fate upon himself; his style is heavy, and his notation cumbrous in the extreme, but his contributions to the subject are of great value and generality, although they attracted no notice for many years, and were re-discovered by others. Unfortunately, they are expressed in such a repulsive notation that no one but an enthusiast would read his works, and the student will feel very grateful to Dr. Muir for his analysis of them. Part of this analysis, in some ways the most interesting, is given on pp. 311–322; this, and the subsequent section on a paper of Sylvester's, deserve careful reading, because, as Dr. Muir points out, Schweins gives some results on alternants which even now are not familiar, and Sylvester makes some hasty statements which, as they stand, appear to be incorrect, but which, if corrected, or rightly interpreted, might lead to important formulæ.

It should be noted that on p. 323 the determinant is misprinted, a, a^2, &c., being put for a_1, a_2, &c. Moreover, it is not explained so clearly as it should be that $\zeta a^r = a_r$; while the law $a_r \cdot a_s = a_{r+s}$ is *not* used. The right statement is $\zeta(a^r \cdot a^s) = \zeta(a^{r+s}) = a_{r+s}$; while $\zeta(a^r)\zeta(a^s) = a_r a_s$. Readers of Sylvester's papers must be careful to distinguish this ζ from the square of the operator $\zeta^{\frac{1}{2}}$. It may be noticed, in passing, that these generalised alternants present themselves in the theory of numbers, both when the elements are roots of unity and also when they are not, so that further knowledge of their properties is desirable, and the suggestion made (p. 325) that Sylvester's results are true when the elements are periodic deserves further examination.

Considerable space is given to functional and orthogonal determinants, and here, of course, Jacobi receives most attention. The results are now so familiar that it requires some effort of imagination to realise the gain in working power which has resulted from Jacobi's investigations. In this connection attention may be directed to an odd remark on p. 297. Speaking of one of Jacobi's papers, Dr. Muir says:—"The only thing worth noticing is the curious cubic equation . . . "; this "curious" equation is nothing more nor less than the reducing cubic for two ternary quadratic forms, in the exact notation of Salmon's "Conics"! And Dr. Muir even takes the trouble to express the invariants Θ, Θ' in the forms

$$Aa' + Bb' + \ldots, \text{\&c.}, \qquad A'a + B'b + \ldots, \text{\&c.},$$

as if this were a quite novel idea.

Returning for a moment to alternants and their applications, attention may be directed to the work of Jacobi and Cauchy on the expansions of rational functions of several variables (pp. 331–345). This is important in the theory of functions, in that of algebraic forms, and in that of partitions. In some ways it deserves further investigation; in various applications the expansions have to be infinite series, and the question of convergency has to be faced, even when the series are used for establishing formal equivalences; this is a curious case of formal and arithmetical algebra each marching, so to speak, on the other's domain.